The symptomatic adult flat foot: Is there a relationship between severity and degree of pre-existing arthritis in the foot and ankle?

Authors: Al-Hourani K [1], Mathews J [1], Shiels S [1], Harries W [1], Hepple S [1], Winson I [1].

1.Department of Orthopaedic Surgery, Southmead Hospital, Bristol, United Kingdom.

Address for correspondence:

Mr Khalid Al-Hourani

Department of Trauma & Orthopaedics

North Bristol NHS Trust

Southmead Road, BS10 5NB

Bristol, United Kingdom

E-mail: kalhourani@doctors.org.uk

Conflicts of interest

None to declare

Introduction

The adult acquired flat food (AFFD) is a potentially debilitating and progressive foot condition with a prevalence thought to be between 3% - 10%.[1] It is characterised by flattening of the medial longitudinal arch, often with posterior tibial tendon dysfunction.[2, 3] More recently, further key structures have been attributed to the pathomechanics of AFFD such as the static stabilisers of the medial arch including the spring ligament complex and posteromedial capsulo-ligamentous structures.[4, 5]

Johnson and Strom have proposed a classification system which describes the pathogenesis of AFFD. This involves a cascade of events beginning with retromalleolar synovitis of the posterior tibial tendon, with subsequent micro-tears, elongation and stretching rendering it unable to perform its function of being the primary medial stabiliser of the foot.[6] Further progression is coupled with failure of static stabilisers such as the spring ligament and plantar fascia, prior to collapse of the medial longitudinal arch. However, it is possible that this cascade of failure may occur in reverse with the static restraints failing first. The final stage leads to involvement of the ankle joint due to the planovalgus nature of the mid foot and hindfoot, as proposed by Myerson et al.[7] It is this progressive nature that is assumed leads to progressive arthritis of the ankle and foot. Despite this, there is no evidence to suggest that progression of AFFD leads to arthritis.

To the authors' best knowledge, no association has been described between severity of AFFD and degree of pre-existing ankle, subtalar or midtarsal arthritis. We aimed to investigate the degree and pattern of pre-existing ipsilateral arthritis of the foot and ankle, in those with symptomatic AFFD, at the time of presentation.

Patients and Methods

Inclusions and exclusion

This was an observational study over a three year period between May 2015 and May 2018. All patients attending the department with variants of AFFD undergo a standard set of standing anteroposterior (AP) and lateral radiographs of the foot and ankle. We subsequently reviewed the radiographs of 161 consecutive patients (over 18 years old) who presented to our orthopaedic outpatient clinic with symptomatic AFFD. We excluded those with diabetes and charcot arthropathy (n=8), previous trauma (n = 2) and those with radiographic evidence of coalition in the hindfoot/midfoot (n = 3), leaving 148 patients for analysis.

The severity of osteoarthritis (OA) was graded using the Kellgren and Lawrence scoring system on AP and lateral radiographs.[8, 9] Measurements were recorded independently by two reviewers (KAH, JAM). The maximum score of four per joint gave a total score of 16 per foot.

The primary outcome measure was severity of OA in the ankle, subtalar, talonavicular and calcaneocuboid joints. Secondary outcome was severity of radiographic planovalgus deformity. The independant variables used were age and severity of planovalgus deformity as measured by the Meary angle, calcaneal pitch and medial cuneiform-fifth metatarsal height. These measurements have been validated by Younger et al.[10] Calcaneal pitch of less than 19 degrees, Meary angle of greater than 10 degrees and medial cuneiform-fifth metatarsal height of less than 6mm were considered abnormal.[11, 12] Anteroposterior and lateral standing X-rays were used to delineate severity of arthritis.

Statistical analysis

All data, such as patient demographics, comorbidities, follow up, complications and radiographic measurements, was stored on a secure database to protect patient confidentiality. This was a retrospective study and therefore institutional review board not required.

Analysis was undertaken with IBM "SPSS" Statistics version 23 (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp). Descriptive statistics were used for categorical data and Shapiro-Wilkes testing of normality for any continuous data. Parametric data was expressed as mean and standard deviation, with non-parametric data as median and interquartile range (IQR). Collinearity testing via data tolerance and variance inflation factors (VIF) for independent variables was carried out. No collinearity was found between the predictor variables considered. A linear regression model was carried out on the primary and secondary outcomes.

Intra- and inter-observer reliability of radiographic measurements was assessed using Cohen's Kappa coefficient (k). Interpretation of agreement was undertaken using the Landis and Koch reference values,[13] where a Kappa value of < 0 indicates no agreement, 0–0.20 as slight agreement, 0.21–0.40 as fair agreement, 0.41–0.60 as

moderate agreement, 0.61–0.80 as substantial agreement, and 0.81–1 as almost perfect observer agreement.

We assumed *a priori* that p values of less than 0.05 were significant. This would show association but not infer causation.

Results

Demographics

One hundred and forty-eight patients were included in final analysis. Median age was 60.0 years (IQR 22). There were 56 males to 92 females, with 75 left sided deformities observed and 73 right sided. Median Meary angle was 17.0 degrees (IQR 7), Calcaneal pitch 19 degrees (IQR 9) and cuneiform-to-fifth metatarsal height of 6.89mm (IQR 6). Mean ankle degenerative score was 0.66 (SD 1.07), subtalar joint 1.03 (SD 1.13), talonavicular joint 1.04 (SD 1.21) and calcaneocuboid joint 0.53 (SD 0.92).

Primary outcome

With increasing severity of planovalgus measurements as the predictor variable, there was no significant association observed in severity of arthritis in the ankle joint ($p = 0.766$), subtalar joint ($p = 0.090$), talonavicular joint ($p = 0.256$) and calcaneocuboid joint ($p = 0.091$).

With increasing age as a predictor variable, there was significance observed in degree of ankle arthritis ($p = 0.001$), subtalar joint ($p = 0.001$), talonavicular joint ($p = 0.001$) and calcaneocuboid joint ($p = 0.004$).

Secondary outcome

There was no significant correlation observed with age for the angular break of Meary's line ($p = 0.73$), calcaneal pitch (0.262) and medial cuneiform-fifth metatarsal height ($p = 0.937$).

Intraobserver reliabilities for grading of ankle, subtalar, talonaviclar and calcaneocuboid arthritis were substantial for observer one ($k = 0.71$, $k = 0.76$, $k = 0.66$ and $k = 0.65$ respectively) and for observer two ($k = 0.70$, $k = 0.71$, $k = 0.67$ and $k = 0.66$ respectively). Interobserver reliability also remained substantial ($k = 0.68$, 0.69, $k = 64$ and $k = 0.66$ respectively).

For severity measurements of Meary angle, calcaneal pitch and medial cuneiform-fifth metatarsal height, intraobserver reliability were moderate for reviewer one ($k = 0.56$, $k = 0.53$ and $k = 0.50$ respectively) and reviewer two ($k = 0.58$, $k = 0.52$ and $k = 0.51$

respectively). Interobserver reliability was also moderate (k = 0.54, k = 0.49 and k = 0.50 respectively).

Discussion

This observational cross-sectional study examines the degree of arthritis at the time of presentation in those with symptomatic planovalgus deformity. It has shown that the talonavicular joint is the most severely affected by arthritis in this population of patients who presented with AFFD, however this was without significance. This is in comparison to the ankle, subtalar and calcaneocuboid joints, which appear to be relatively spared. This seemed to have a greater predominance amongst the older population as opposed to younger adults.

Gait analysis studies by Turner et al have shown altered biomechanics in those with pes planovlagus compared to matched control adults. There was an increased contact stress, time and area over the medial midfoot in comparison to the lateral midfoot. Additionally, there were higher forces acting across the subtalar joint particularly in the heel-strike through to mid-stance phase.[14] In a further study by Caravaggi et al, static and kinematic analysis in paediatric planovalgus was also analysed, showing that the mid tarsal joint was

dorsiflexed, everted and abducted throughout gait, potentially leading to this progressive deformity with increasing age.[15] This deformity seems to be placing a restriction on normal movement.[16] Furthermore, the increased likelihood of talonavicular osteoarthritis has been assessed in 32 planovalgus feet by Cowie et al. Using an electric goniometer, the medial column of the foot was found to be pathologically more mobile in flexion and extension with increased lateral displacement forces.[17] The increased forces across the talonavicular joint have further been confirmed by Kitaoka et al in a series of biomechanical studies.[18-20] The authors therefore postulate that the abnormal biomechanics across the medial column in force, movement and translation, leads to pathological load on the talonavicular joint and great degree of degenerative joint disease. Our study appears to back these findings.

Menz et al has previously undertaken a cross-sectional study of the elderly population examining the midfoot and its association to flat feet. Their results indicated that those with talonavicular joint osteoarthritis had significantly higher rates of flat foot on radiological and clinical parameters.[21] However, other joints were not assessed for evidence of osteoarthritis radiographically. Sangeorzan et al have also looked at this topic in the past utilising simulated weight bearing computed tomography to investigate these patients, finding no correlation between severity of condition or arthritis with age. Furthermore, no correlation was observed degree of foot deformity and degenerative change.[22]. Limitations of this study were low patient numbers, as well as method of assessing this deformity, which is not generalisable to a clinic setting. Our study utilises greater patient numbers and standard radiographs as a method of assessment in a standard clinic setting, which is what the vast majority of these patients experience. Additionally we have observed

a cross section of all adult age groups, and age as a predictor variable has been shown to be associated with degenerative change.

To the authors' best knowledge, this study is the largest cross-sectional observational cohort in the literature that assesses association of planovalgus feet with osteoarthritis of the ankle, subtalar and midtarsal joints. Furthermore, our radiological and arthritis scores were subject to high inter and intra-observer reliability, and therefore we are confident with the reproducibility and results shown and the contribution to our understanding of the observations of this condition, a key factor in informing the patient in clinic.

This study however is subject to limitations. A cross-sectional study is able to infer an association but not causation, and therefore we are unable to show whether the arthritis caused the planovalgus or vice versa. The biomechanical studies seem to show that planovalgus leads to degeneration as described above. Furthermore, the Kellgren and Lawrence scoring system is not a validated scoring system for arthritis in the foot and ankle. This system has a ceiling effect, since those beyond >50% narrowing cannot be captured. Furthermore, it does not include deformity as part of its staging. Therefore a staging system which encompasses both degree of OA and degree of deformity (particularly that of talocalcaeno-navicular complex) would be most suitable. The authors are unaware of a validated system that could otherwise have been used. Oblique view of the foot were not used as a standard assessment tool and this could have given further information with regards to the changes seen at the level of the chopart joint. Finally, a comparative group to assess the level of degenerative change in the general population may have been useful as a comparative group, however it is important to note that this study offers a cross-sectional

observational study of patients with the symptomatic condition only and not intended to offer causative factors.

Conclusion

This study shows no significant association between severity of radiographic planovalgus deformity and arthritis of the ankle, hindfoot an midtarsal joints at the time of presentation in symptomatic AFFD. However, the relationship between the altered biomechanics and severity of medial midtarsal osteoarthritis appears to be plausible and warrants further investigation in prospective studies.

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